D Indicates conditions in which speed and the ability to maneuver are severely restricted due to traffic congestion.

E Indicates full capacity; a disruption, no matter how minor, causes backups to form.

F Indicates breakdown of flow or stop-and-go traffic.

Each level is defined by a range of volume-to-capacity ratios. Level of service A, B, or C is considered good operating conditions in which minor or tolerable delays of service are experienced by motorists. Level of service D represents below average conditions. Level of service E corresponds to the maximum capacity of the roadway. Level of service F indicates a heavily congested or overburdened capacity. Roads outside the Las Vegas metropolitan area are generally level of service A or B; roads inside the Las Vegas metropolitan area are generally level of service E or F. Table 3-60 lists current levels of service on potential heavy-haul truck routes (excluding the planned Las Vegas Beltway).

Table 3-60. Existing levels of service along candidate routes for heavy-haul trucks.[a]

Route segment	Level of service
Caliente	
U.S. 93 to U.S. 6/U.S. 95 interchange	A
U.S. 95/U.S. 6 to Tonopah city limit	C
U.S. 95 (to Mercury, Nevada)	B
Caliente/Chalk Mountain	
Caliente to Rachel	A
Cost of route on U.S. Government Facility	N/A
Caliente/Las Vegas	
U.S. 93 (between I-15 and Caliente)	A
I-15 (to Craig interchange)	A
I-15 (in Las Vegas)	E or F[b]
U.S. 95 (in Las Vegas)	E or F[b]
U.S. 95 (Las Vegas to Mercury)	B
Sloan/Jean	
I-15 (to and in Las Vegas)	C, F[b]
U.S. 95 (in Las Vegas)	C, F[b]
U.S. 95 (Las Vegas to Mercury)	B
Apex/Dry Lake	
I-15 (to Craig interchange	A
I-15 (in Las Vegas)	E and F[b]
U.S. 95 (in Las Vegas)	E and F[b]
U.S. 95 (Las Vegas to Mercury)	B

a. Source: DIRS 103225-DOE (1998, pp. 3-1 to 3-14).
b. Does not consider the Las Vegas Beltway.

3.3 Affected Environment at Commercial and DOE Sites

In response to public comments, DOE has revised Section 3.3 to provide more information on the methodology the Department used to determine baseline conditions at the 72 commercial and 5 DOE sites evaluated under the No-Action analysis. The revisions include added information on the individual site environmental factors (Section 3.3.1) and augmented information on regional environmental factors (Section 3.3.2). In providing this new information, DOE changed the section numbers for the information that appeared in the Draft EIS.

The No-Action Alternative analyzes the impacts of not constructing and operating a monitored geologic repository at Yucca Mountain. It assumes that the spent nuclear fuel and high-level radioactive waste would remain at commercial and DOE sites throughout the United States. This section describes baseline environmental factors at commercial and DOE sites including land use requirements, radiological effluents, worker and offsite populations, and occupational and public radiation doses. These factors provide a basis for comparison of impacts with the Proposed Action and the No-Action Alternative.

In addition to the site environmental factors, this section also includes regional environmental factors for five regions of the United States, including climate, groundwater, waterways, and potentially affected populations. These regional parameters provide the baseline information necessary for estimating potential impacts resulting from the No-Action Alternative Scenario 2 described in Chapter 7 of the EIS.

3.3.1 SITE ENVIRONMENTAL FACTORS

3.3.1.1 COMMERCIAL SITES

At present, there are 103 operating commercial nuclear powerplants at 69 sites in 31 of the contiguous United States. In addition, three sites (Trojan in Oregon, and Humboldt Bay and Rancho Seco in California) have reactors in various stages of decommissioning. The locations of the 72 commercial nuclear powerplants evaluated in this EIS are shown in Figure 3-33. Approximately half of these sites contain two or three nuclear units. There are no commercial nuclear powerplants in Alaska or Hawaii.

3.3.1.1.1 *Land Use and Ownership*

Typically, nuclear powerplant sites and the surrounding areas are flat-to-rolling countryside in wooded or agricultural areas. More than half of the sites have 80-kilometer (50-mile) population densities of fewer than 200 persons per square mile, and more than 80 percent have 80-kilometer densities of fewer than 500 persons per square mile (DIRS 101899-NRC 1996, Section 2.2.1, p. 2-2). The most notable exception is the Indian Point Station, which is within 80 kilometers of New York City, which has a population density of more than 2,000 persons per square mile.

Site areas range from 0.34 square kilometer (84 acres) for the San Onofre Nuclear Generating Station in California to 120 square kilometers (30,000 acres) for the McGuire Nuclear Station in North Carolina. More than half of the plant sites encompass 2 to 8 square kilometers (500 to 2,000 acres). Larger land use areas are usually associated with plant cooling systems that include reservoirs, artificial lakes, and buffer zones. Typically, 0.2 to 0.4 square kilometer (50 to 100 acres) might actually be disturbed during plant construction. Other land commitments can amount to many tens of square kilometers for transmission line rights-of-way and cooling lakes (if used).

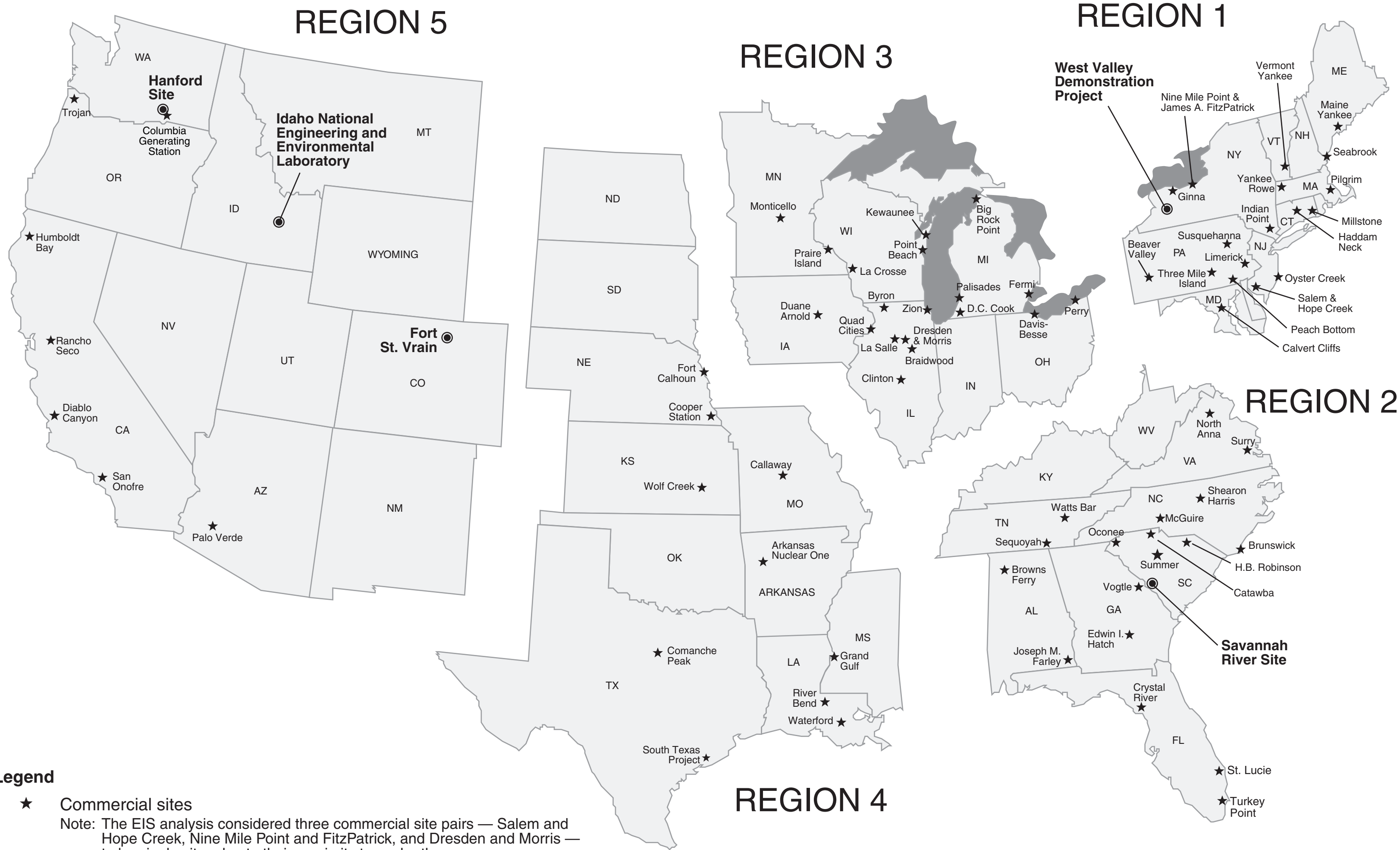
In general, these sites are owned and maintained by the investor owned utilities (sites operated by the Tennessee Valley Authority are Federally owned) that operate the associated power plants and control egress to the sites to protect the health and safety of the public.

3.3.1.1.2 *Socioeconomic Environment*

Although the size of the workforce varies considerably among sites, the average permanent staff size at a nuclear powerplant ranges from 800 to 2,400 people, depending on the number of operating units at the site (DIRS 101899-NRC 1996, Section 2.3.8.1, p. 2-26). In rural or low-population communities, the number of permanent jobs can represent a substantial portion of the local workforce.

In addition to the permanent workforce, many temporary workers are required for tasks that occur during refueling and maintenance outages. Between 200 and 900 additional workers can be employed during these outages to perform the normal maintenance work. Although these temporary workers are in the community for only a short time (usually 1 to 2 months a year), they can have a substantial effect on the area (DIRS 101899-NRC 1996, Section 2.3.8.1, p. 2-27).

In addition to direct employment, plant subcontractors and service industries in the area provide hundreds of indirect jobs. In rural communities, industries that provide this number of jobs at relatively high wages are major contributors to the local economy. In addition to the beneficial effect of these jobs, plant purchasing and worker spending can generate considerable income for local businesses (DIRS 101899-NRC 1996, Section 2.3.8.2, p. 2-28).



Legend

★ Commercial sites

Note: The EIS analysis considered three commercial site pairs — Salem and Hope Creek, Nine Mile Point and FitzPatrick, and Dresden and Morris — to be single sites due to their proximity to each other.

◉ DOE sites

Note: The EIS analysis included the high-level radioactive waste at West Valley. The State of New York owns the high-level radioactive waste and the site. Under the West Valley Demonstration Project Act, DOE is responsible for solidifying and transporting the high-level radioactive waste to a repository.

Note: None of the facilities evaluated are located in Alaska or Hawaii.

Symbols do not reflect precise locations.

Source: Modified from DIRS 101911-Poe (1998, p. 2).

Figure 3-33. Commerical and DOE sites in each No-Action Alternative analysis region.

A nuclear powerplant represents an investment of several billion dollars. Such an asset on the tax rolls is extraordinary for rural communities and can constitute the major source of local revenues for small or remote taxing jurisdictions. This revenue often enables higher quality and more extensive public services with lower tax rates to the citizens (DIRS 101899-NRC 1996, Section 2.3.8.2, p. 2-28).

For these reasons, nuclear powerplants can have a significant positive effect on the local community environment. These effects are stable and long-term. Because these effects generally enhance the economic structure of the local community, nuclear powerplants become a major positive contributor to the local area (DIRS 101899-NRC 1996, Section 2.3.8.2, p. 2-28).

3.3.1.1.3 *Radioactive Effluents*

During normal operations, nuclear powerplants release small amounts of radioactive materials to the environment through atmospheric and aquatic pathways. These radioactive materials, released under controlled conditions, include fission and activation products. Releases to the atmosphere consist primarily of the noble gases and some of the more volatile materials like tritium, isotopes of iodine, and cesium. Releases to aquatic pathways consist primarily of nonvolatile fission and activation products such as isotopes of cesium and cobalt. After appropriate holdup and processing, these materials are monitored carefully before and during releases to determine whether the licensed release limits can be met (for example, 10 CFR Part 20, Appendix I to 10 CFR Part 50, 10 CFR 50.36a, and 40 CFR Part 190).

In 1993 (the last year for which information is readily available), boiling-water and pressurized-water reactors released about 31,000 and 28,000 curies, respectively, of fission and activation gases to the atmosphere (DIRS 155108-Tichler, Doty, and Lucadamo 1995, Tables 1 and 2, pp. 6-12). Thus, the estimated average atmospheric release per boiling-water reactor and pressurized-water reactor was 760 and 380 curies per year, respectively.

In addition, boiling-water reactors and pressurized-water reactors released 0.75 and 0.30 curies, respectively, of iodine-131 and particulates to the atmosphere (DIRS 155108-Tichler, Doty, and Lucadamo 1995, Tables 3 and 4, pp. 12-17). This resulted in boiling-water reactor and pressurized-water reactor average unit releases of 0.018 and 0.0041 curies, respectively.

Liquid releases of tritium in 1993 for boiling-water reactors and pressurized-water reactors totaled about 530 and 36,000 curies, respectively (DIRS 155108-Tichler, Doty, and Lucadamo 1995, Tables 5 and 6, pp. 18-24), and about 11 and 35 curies, respectively (DIRS 155108-Tichler, Doty, and Lucadamo 1995, Tables 7 and 8, pp. 24-29), of mixed fission and activation products.

3.3.1.1.4 *Occupational and Public Health and Safety*

Occupational Radiation Exposures

Nuclear plant workers who conduct activities involving radioactively contaminated systems or who work in radiation areas can be exposed to radiation. Most of the occupational radiation dose to such workers results from external radiation rather than internal exposure to inhaled or ingested radioactive materials. Pursuant to reporting requirements of 10 CFR 20.2206, the Nuclear Regulatory Commission received annual reports from 104 licensees that operated commercial nuclear power reactors in 1999. These reports consisted of radiation exposure records for each monitored individual. The reports are analyzed for trends and summarized in annual reports (DIRS 155099-Karagiannis and Hagemeyer 2000, all) in terms of collective dose and the distribution of dose among the monitored individuals.

In 1999, the total collective occupational dose for all operating commercial reactors was almost 14,000 person-rem or an average per licensee of 131 person-rem (DIRS 155099-Karagiannis and Hagemeyer 2000, Table 3.2, p. 3-5). This total collective dose was received by about 114,000 monitored workers for an average annual individual dose of 120 millirem, which is about 40 percent of the average background radiation dose for the United States, as listed in Table 3-30. However, of the 114,000 monitored workers, about half (55,000 workers) had no measurable dose. Of the approximately 59,000 workers who had a measurable dose, the estimated annual average radiation exposure was 230 millirem, or about 77 percent of the national average background radiation dose of 300 millirem.

In addition to nuclear powerplant licensees, in 1999 the Nuclear Regulatory Commission received annual radiation exposure reports from two Independent Spent Nuclear Storage Facility operators. The reported annual collective dose for these two licensees was 5 person-rem received by 86 monitored individuals, for an annual average of 60 millirem. Of the monitored individuals, only 33 received measurable radiation doses for an annual average of 150 millirem. These doses represent 20 and 50 percent, respectively, of the national average background radiation dose of 300 millirem.

Public Radiation Exposures

Releases of radioactive materials from nuclear power reactors result in radiation doses to humans that are small in relation to doses from natural background radiation. Persons can be exposed to radiation from nuclear power reactors through atmospheric and aquatic pathways. When an individual is exposed through one of these pathways, the dose is determined by the amount of the radioactive material a person could inhale or ingest. The amount of radioactive material inhaled or ingested is determined by the exposure time and the radioactive material concentrations in the various environmental media. The resulting dose is determined by radionuclide-specific dose conversion factors, which are based on physical decay and metabolic properties of the radioactive material in the body.

The major exposure pathways include the following:

- Inhalation of contaminated air
- Drinking milk or eating meat from animals that graze on open pasture on which radioactive contamination might fall
- Eating vegetables grown near the site
- Drinking water or eating fish caught near the point of discharge of liquid effluents

Other less important exposure pathways include external irradiation from surface deposition; consumption of animals that drink irrigation water that might contain liquid effluents; consumption of crops grown near the site using irrigation water that might contain liquid effluents; shoreline, boating, and swimming activities; and direct radiation to offsite individuals.

In 1992 (the last year for which information is readily available), the estimated total population doses for populations living within 80 kilometers (50 miles) of operating nuclear power reactors were 32 person-rem by waterborne pathways and 15 person-rem by airborne pathways, for a total of 47 person-rem (DIRS 155092-Aaberg and Baker 1996, Table 1.4, p. 1.9). However, estimated population dose commitments for the waterborne and airborne pathways varied widely among the sites. The total dose commitments from both pathways for individual sites varied from a high of 3.7 person-rem to a low of 0.0015 person-rem. The arithmetic mean for the total dose from liquid pathways (0.44 person-rem) and airborne pathways (0.21 person-rem) was 0.66 person-rem (DIRS 155092-Aaberg and Baker 1996, p. 1.11). The estimated average annual dose to the offsite individual living within 80 kilometers was 0.0003 millirem, which is a very small fraction of the average annual dose from natural background radiation of 300 millirem in the United States.

In addition to average population doses, maximally exposed individual doses were estimated for commercial nuclear power sites for comparison with the 10 CFR Part 50, Appendix I, numerical guides for design objectives [10 CFR 50.34a(a)], which require nuclear powerplant licensees to design and operate their facilities in a manner that maintains offsite doses from liquid and atmospheric effluents *as low as reasonably achievable*. For the more than 70 sites reporting in 1992, the arithmetic mean of the maximum annual dose from atmospheric pathways for an offsite individual living at the nearest residence was about 0.012 millirem from releases of noble gases and 0.27 millirem to any organ (thyroid, lung, etc.) from releases of iodines and particulate material. For the liquid pathways, the arithmetic mean of the *maximally exposed individuals* for all reporting sites was about 0.12 millirem (DIRS 155092-Aaberg and Baker 1996, Table 1.4, p. 1.9).

For the waterborne pathways, tritium, zinc-65, and isotopes of cesium accounted for 31, 14, and 43 percent of the total dose, respectively. For the airborne pathways, tritium and isotopes of xenon accounted for 44 and 46 percent of the dose, respectively (DIRS 155092-Aaberg and Baker 1996, Table 1.8, pp. 1.17 through 1.22).

3.3.1.2 DOE SITES

This EIS focuses on the five DOE sites at which spent nuclear fuel and high-level radioactive waste currently exists or where existing Records of Decision have authorized placement of these materials (see Chapter 7, Section 7.2 for details). The five sites are the Hanford Site, the Idaho National Engineering and Environmental Laboratory, Fort St. Vrain (spent nuclear fuel only), the West Valley Demonstration Project (high-level radioactive waste only), and the Savannah River Site (Figure 3-33).

3.3.1.2.1 *Land Use and Ownership*

Of the five DOE sites that manage spent nuclear fuel and high-level radioactive waste, three (Hanford Site, Idaho National Engineering and Environmental Laboratory, Savannah River Site) are on large tracts of Federally owned land ranging from 2,300 square kilometers (890 square miles) for Idaho National Engineering and Environmental Laboratory to 800 square kilometers (310 square miles) for the Savannah River Site. On these three sites, most of the land is undeveloped or forest management areas. These undeveloped areas serve as buffer zones between the operating areas and the public. Access to these sites is controlled for national security purposes to prevent ingress by unauthorized personnel.

The Fort St. Vrain Independent Spent Nuclear Fuel Installation and West Valley Demonstration Project are on much smaller tracts of land, 3.8 acres and 220 acres, respectively, which are mostly developed but are surrounded by low-population-density lands used mostly for agricultural and residential purposes.

3.3.1.2.2 *Socioeconomic Environment*

Because of their large employment base, the Hanford Site, Idaho National Engineering and Environmental Laboratory, West Valley Demonstration Project, and Savannah River Site represent a substantial portion of their respective local workforces. For example, in December 1997 the Hanford Site employed almost 11,000 DOE and contractor personnel, which represented 13 percent of the total employment in the area (DIRS 156931-DOE 2000, p. 4-101). Similarly, in 1998 Idaho National Engineering and Environmental Laboratory and Savannah River Site employed 8,100 and 14,000 workers, respectively, which represented about 7 percent of their local area workforces (DIRS 156914-DOE 2000, all). In 1993, the West Valley Demonstration Project employed more than 1,000 DOE and contract workers and was the largest local employer; these workers represented almost 4 percent of the local workforce (DIRS 101729-DOE 1996, p. 4-58).

In 1995, approximately 230 persons worked at the Fort St. Vrain site. Of these, approximately 16 full-time-equivalent personnel worked on the Independent Spent Fuel Storage Facility (DIRS 103213-DOE 1996, Appendix E, Section 3, pp. 3-53 and 54). Based on the 1980 census, the population within an 8 kilometer (5-mile) radius of the site was 3,148, with 1,662 residing in the Town of Platteville. The projected population for 2012 (through the 20-year license) for this area will be 4,526, with 3,040 residing in Platteville. However, even with this relatively small local workforce, the 16 workers and the DOE site would have minimal impact.

In addition to base employment, DOE sites contribute to the local economic conditions through the creation of indirect employment and through the purchase of goods and services from local firms.

3.3.1.2.3 *Radioactive Effluents*

As a result of ongoing process and *remediation* activities, most DOE sites routinely release quantities of radioactive materials to the atmosphere and surface waters that eventually enter the surrounding environment. These effluents are carefully monitored at their points of discharge to ensure that releases remain within limits specified by DOE Orders and applicable state and Federal statutes and regulations.

Radioactive materials released from DOE sites consist of fission and activation products (such as tritium, cesium, strontium, iodine, and krypton), transuranics (such as plutonium and americium), and source material (such as uranium). Atmospheric releases consist primarily of tritium and noble gases (such as krypton and argon), and liquid releases consist primarily of tritium with much smaller quantities of fission products and transuranics. The Idaho National Engineering and Environmental Laboratory typically does not release radioactive liquid effluents off the site. Rather, liquid effluents are sent to two plastic-lined evaporation ponds (DIRS 156914-DOE 2000, Section 7.1, p. 7-3) that prevent percolation of contaminated water into the ground and eventual release to the *accessible environment*. In addition, the Hanford Site 200-Area facilities discharge radioactive liquid effluents to the 616-A-Crib (also known as the State-Approved Land Disposal Site) rather than directly to the Columbia River (DIRS 156931-DOE 2000, Section 3.1.3, p. 3.6). The Fort St. Vrain site does not have atmospheric or liquid effluents (DIRS 155101-DOE 1998, Section 2.3.4.1, p. 2-25 and Section 2.4.2, p. 2-35) because the spent nuclear fuel is stored in sealed canisters and is not typically handled or processed.

In 1999, the four DOE sites with radioactive effluents discussed in this section released about 92,000 *curies* of fission and activation products to the atmosphere (DIRS 156914-DOE 2000, Table 7-1, p. 7-4; DIRS 156931-DOE 2000, Table 3.1.1, p. 3.6; DIRS 155094-Arnett and Mamatey 2000, Table 4, p. 13; DIRS 154284-WVNS 2000, Tables D-2 through D-11, pp. D-4 through D-12). Most of these releases occurred at the Savannah River Site, which released about 89,000 curies. The Savannah River Site atmospheric releases consisted almost entirely of tritium (about 52,000 curies) and noble gases (about 37,000 curies). In addition, the four sites released 0.0025 curie of transuranics and 0.048 curie of source material to the atmosphere.

In 1999, the DOE sites released about 6,400 curies of fission and activation products in liquid effluents (DIRS 156914-DOE 2000, Table 7-2, p. 7-5; DIRS 156931-DOE 2000, Tables 3.1.3 and 3.1.4, p. 3.7; DIRS 155094-Arnett and Mamatey 2000, Table 6, p. 22; and DIRS 154284-WVNS 2000, Table C-1, p. c-3). More than 99 percent of these releases consisted of tritium, and most (about 6,300 curies) occurred at the Savannah River Site.

3.3.1.2.4 *Occupational and Public Health and Safety*

Occupational Radiation Exposures

In 1999, DOE reported a total workforce (including contractors) of approximately 130,000 individuals (DIRS 155091-DOE 1999, Exhibit 3-1, p. 3-2). Of these individuals, about 113,000 were monitored for potential radiation exposure. Only about 17,000 received measurable doses. The collective dose is the sum of the doses received by all individuals who had measurable doses, and is reported in person-rem. The collective dose is an indicator of the overall radiation exposure at DOE facilities and includes doses to all DOE employees, contractors, and visitors. DOE monitors the collective dose as one measure of the overall performance of radiation protection programs to keep individual and collective exposures as low as reasonably achievable.

For the five sites discussed in this section, DOE reported a total collective dose of about 380 person-rem for 1999 (DIRS 155091-DOE 1999, Exhibit 3-17, p. 3-17). This dose was received by almost 6,000 individuals with measurable doses, for an average annual dose of about 60 millirem per person. This dose represents 20 percent of the national average background dose of 300 millirem. The Fort St. Vrain site reported no measurable doses for 1999.

Public Radiation Exposures

In a manner similar to that described in Section 3.3.1.1.4 for commercial sites, DOE estimates collective and individual doses for populations living within 80 kilometers (50 miles) of their operations facilities. In 1999, for the five DOE sites discussed in this section, the total estimated offsite population dose was about 7.1 person-rem. This dose was received by a total 80-kilometer population of about 2.5 million people for an average dose of about 0.003 millirem per person, which is a very small fraction of the average annual dose from natural background radiation of 300 millirem in the United States (DIRS 156914-DOE 2000, Table 8-3, p. 8-9; DIRS 156931-DOE 2000, Table 5.0.2, p. 5.9; DIRS 155090-Arnett and Mamatey 2000, Table 7-2, p. 118, p. 121; DIRS 155094-Arnett and Mamatey 2000, Table 32, p. 125; DIRS 154284-WVNS 2000, Table 4-2, p. 4-7). Most of this collective dose (6.6 person-rem) was received by persons living around and downstream of the Savannah River Site and is attributed to atmospheric and liquid releases of tritium (3.5 person-rem) (DIRS 155094-Arnett and Mamatey 2000, Table 41, p. 135 and Table 48, p. 144). Fort St. Vrain reported that radioactive effluents and direct radiation from the site in 1999 did not contribute to any increase in offsite doses (DIRS 155093-Newkirk and Hall 2000, p. 7).

In addition to average population doses, DOE estimated doses for the hypothetical maximally exposed offsite individual. For the four sites with reported offsite doses, the maximally exposed offsite individual received a maximum dose of 0.28 millirem (DIRS 155100-DOE 1999, p. 8-4; DIRS 155097-DOE 1999, p. 5.4; DIRS 155090-Arnett and Mamatey 2000, p. 122; DIRS 154284-WVNS 2000, Table 4-2, p. 4-7), primarily from atmospheric and liquid releases of tritium (0.10 millirem) and liquid releases of cesium-137 (0.13 millirem) (DIRS 155094-Arnett and Mamatey 2000, Table 42, p. 136, and Table 45, p. 141).

3.3.2 REGIONAL ENVIRONMENTAL FACTORS

For analytic purposes, DOE divided the country into five regions (see Figure 3-33). This section describes the affected environment for each region that reflects the average or mean conditions of the sites in the region. The affected environment includes spent nuclear fuel and high-level radioactive waste inventories, climatic parameters, groundwater flowrates, downstream surface-water users, and downstream surface-water flowrates. In all cases, DOE used data consisting of average or mean conditions from actual sites to develop hypothetical sites.

To develop the hypothetical sites, DOE divided the generator sites among the five regions (Figure 3-33). Climate varies considerably across the United States. Radionuclide release rates would depend primarily on the interaction of climate and materials. DOE analyzed release rates for a hypothetical site in each region that was a mathematical representation of the actual sites in that region. The development process for the hypothetical site used weighted values for material inventories, climate, and groundwater flow information from each actual site to ensure that the results of the analyses of the hypothetical site were comparable to the results for each actual site, if analyzed independently. Similarly, the process constructed downstream populations of water users and river flow for the hypothetical sites from population and river flow data for actual sites, so they reflect the populations downstream of actual storage facilities and the actual amount of water those populations use.

3.3.2.1 REGIONAL INVENTORIES OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE

Table 3-61 lists the Proposed Action quantities of commercial spent nuclear fuel, DOE spent nuclear fuel, and high-level radioactive waste in each of the five regions. The information in the table is a projection of quantities and forms that would exist at a point in the future, not as they currently exist. For example, high-level radioactive waste is listed in the table as having gone through a vitrification process with subsequent packaging in canisters, as if ready for disposal in a repository.

Table 3-61. Proposed Action quantities of spent nuclear fuel (metric tons of heavy metal) and canisters of high-level radioactive waste in each geographic region.[a,b]

Region	Commercial spent nuclear fuel[c,d]	DOE spent nuclear fuel[e]	High-level radioactive waste[f,g]
1	16,800	0	300
2	18,900	30	6,000
3	14,700	0	0
4	7,200	0	0
5	5,400	2,300	2,000
Totals	63,000	2,300	8,300

a. Source: Appendix A.
b. Totals might differ from sums due to rounding.
c. Analyzed as stored on surface, as shown on Chapter 2, Figures 2-32, 2-33, and 2-34.
d. Includes plutonium in mixed-oxide spent nuclear fuel, which is assumed to behave like other commercial spent nuclear fuel.
e. A representative or surrogate fuel that consisted primarily of N-reactor fuel.
f. Includes plutonium in can-in-canister.
g. Historically, a canister of high-level radioactive waste has been assumed to be equivalent to about 0.5 MTHM (see Appendix A, Section A.2.3.1).

3.3.2.2 CLIMATIC FACTORS AND MATERIAL

DOE assumed that a single hypothetical site in each region would store all the spent nuclear fuel and high-level radioactive waste in each region. Such a site does not exist, but DOE used it for this analysis. To ensure that the calculated results of the regional analyses reflected the appropriate inventory, facility and material degradation, and radionuclide transport, DOE developed the spent nuclear fuel and high-level radioactive waste inventories, engineered barriers, and environmental parameters for the hypothetical site from data from the actual sites in that region. Weighting criteria accounted for the different amounts and types of spent nuclear fuel and high-level radioactive waste at each site, so the results of the analyses of the hypothetical site were representative of the sum of the results if DOE had modeled each actual site independently. If there are no storage areas in a particular part of a region, DOE did not analyze the environmental parameters of that part (for example, there are no storage facilities in the Upper Peninsula of Michigan, so the analysis for Region 3 did not include environmental parameters from cities in the Upper Peninsula). In addition, if the storage area would not affect drinking water (for example, groundwater near the Calvert Cliffs Nuclear Generating Plant outcrops to the Chesapeake Bay), the regional hypothetical storage facility did not include their fuel inventories.

The following climate parameters are important to material degradation times and rates of release:

- Precipitation rate (amount of precipitation per year)
- Rain days (percent of days with measurable precipitation)

- Wet days (percent of year that included rain days and days when the relative humidity was greater than 85 percent)
- Temperature
- Precipitation chemistry (pH, chloride anions, and sulfate anions)

Table 3-62 lists the regional values for each parameter. Appendix K contains more information on the selection and analysis of these parameters.

Table 3-62. Regional environmental parameters.

Region	Precipitation rate (centimeters per year)[a]	Percent rain days (per year)	Percent wet days (per year)	pH	Precipitation chemistry: Chloride anions (weight percent)	Precipitation chemistry: Sulfate anions (weight percent)	Average temperature (ºC)[b]
1	110	30	31	4.4	6.9×10^{-5}	1.5×10^{-4}	11
2	130	29	54	4.7	3.9×10^{-5}	9.0×10^{-5}	17
3	80	33	42	4.7	1.6×10^{-5}	2.4×10^{-4}	10
4	110	31	49	4.6	3.5×10^{-5}	1.1×10^{-4}	17
5	30	24	24	5.3	2.1×10^{-5}	2.5×10^{-5}	13

a. To convert centimeters to inches, multiply by 0.3937.
b. To convert degrees Centigrade to degrees Fahrenheit, add 17.78 and then multiply by 1.8.

3.3.2.3 GROUNDWATER PARAMETERS

Most of the radioactivity and metals from degraded material would seep into the groundwater and flow with it to surface outcrops to rivers or streams. Therefore, the analysis had to account for the groundwater characteristics at each site, including the time it takes the water to move through the unsaturated zone and the aquifer. The analysis assumed that the storage facilities would be 490 meters (1,600 feet) up the groundwater gradient from the hypothetical reactor and used this assumption to calculate the time it would take contaminants to reach surface water. Table 3-63 lists the ranges of groundwater flow times in each region. Appendix K contains more information on the sources of groundwater data.

Table 3-63. Ranges of flow time (years) for groundwater and contaminants in the unsaturated and saturated zones in each region.

Region	Contaminant K_d[a] (milliliters per gram)	Unsaturated zone: Water flow time	Unsaturated zone: Contaminant flow time	Saturated zone: Groundwater flow time	Saturated zone: Contaminant flow time	Total contaminant flow time
1	0[b] - 100	0.7 - 4.4	0.4 - 2,100	0.3 - 56	10 - 5,000	10 - 6,000
2	10 - 250	0.6 - 10	35 - 5,000	3.3 - 250	11 - 310,000	460 - 310,000
3	10 - 250	0.5 - 14	32 - 1,500	1.3 - 410	9 - 44,000	65 - 45,000
4	10 - 100	0.2 - 7.1	110 - 2,300	3.9 - 960	300 - 520,000	460 - 520,000
5	0 - 10	0.9 - 73	14 - 4,700	1.7 - 170	0 - 25,000	200 - 26,000

a. K_d = equilibrium adsorption coefficient.
b. The K_d would be 0 if there was no soil at the site.

3.3.2.4 AFFECTED WATERWAYS

Most of the estimated population dose for the No-Action Alternative would be a result of drinking contaminated surface water. The first step in determining the population dose was to identify the waterways that receive groundwater from beneath existing storage facilities (Figure 3-34) and the number of public drinking water systems that draw water from the potentially contaminated waterways

Figure 3-34. Major waterways near commercial and DOE sites.

(Table 3-64). DOE calculated the river flow past each population center (Section 3.3.2.5) along each river, and used this number in the calculation to determine dose to the population.

Table 3-64. Public drinking water systems and the populations that use them in the five regions.[a]

Region	Drinking water systems	Population
1	85	10,000,000
2	150	5,600,000
3	150	12,000,000
4	95	600,000
5	6	2,800,000
Totals	***486***	***31,000,000***

a. Sources: Based on current information and the 1990 census.

3.3.2.5 AFFECTED POPULATIONS

After identifying the affected waterways, DOE identified the populations that get their drinking water from those waterways. The total population using the river was expressed as number of people per cubic foot per second. If a river system traverses more than one region (for example, the Mississippi drains three regions), weighting criteria accounted for materials received from storage facilities upstream of the region that would flow past several downstream population centers, as necessary. Table 3-64 lists the number of people using the public drinking water systems potentially affected by the degradation of radioactive materials.

REFERENCES

Note: In an effort to ensure consistency among Yucca Mountain Project documents, DOE has altered the format of the references and some of the citations in the text in this Final EIS from those in the Draft EIS. The following list contains notes where applicable for references cited differently in the Draft EIS.

155092 Aaberg and Baker 1996 Aaberg, R.L. and Baker, D.A. 1996. *Dose Commitments Due to Radioactive Releases from Nuclear Power Plant Sites in 1992.* NUREG/CR-2850, Vol. 14. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 241611.

103069 AAR 1996 AAR (Association of American Railroads) 1996. *Railroad Facts.* 1996 Edition. Washington, D.C.: Association of American Railroads. TIC: 243890.

103070 ACGIH 1999 ACGIH (American Conference of Governmental Industrial Hygienists) 1999. *1999 TLVs® and BEIs®, Threshold Limit Values for Chemical Substances and Physical Agents, Biological Exposure Indices.* Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists. TIC: 243476.

156932 AIET 2000 AIET (American Indian Ethnography Team) 2000. *Preliminary Cultural Assessment of Wildhorse Spring and the Willow Springs Complex on and Near the Nellis Air Force Range.* Las Vegas, Nevada: Nellis Air Force Base.

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